



# VACET

## Science Impact Highlights

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28 April 2009

[www.vacet.org](http://www.vacet.org)

Ultimately, it's about “understanding”

The purpose of computing is insight, not numbers.

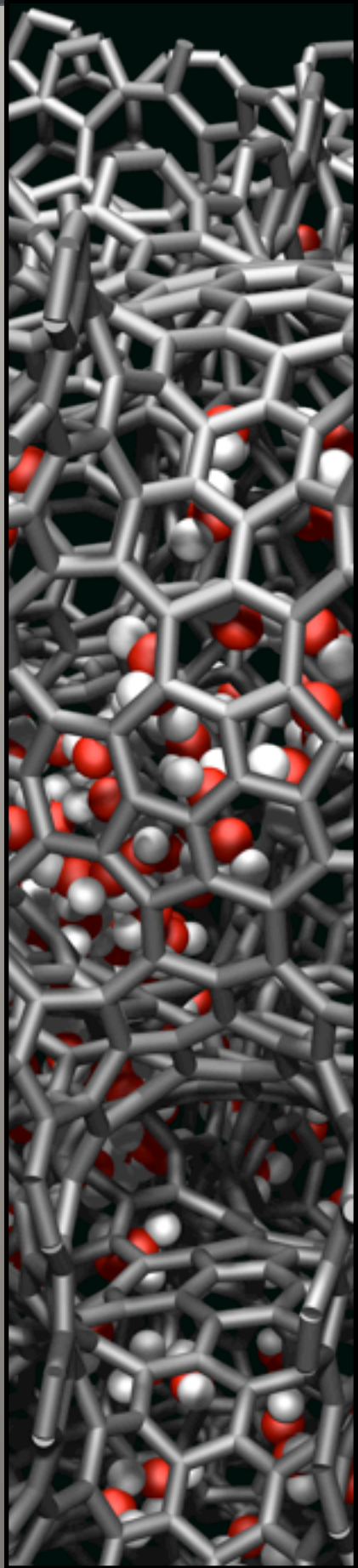
– *Richard Hamming*

The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny ...'

– *Isaac Asimov*

# Large Data Visualization Issues

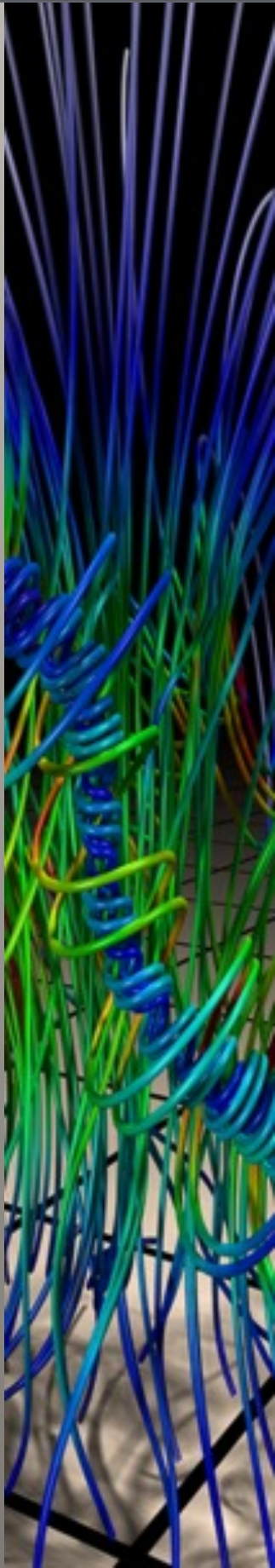
- Existing, traditional algorithms don't work
  - HPC Challenges (resolution, multivariate, etc.)
  - Human cognition challenges
- We listen to our science stakeholders. They want:
  - To analyze and understand relevant and scientifically interesting data
  - To compute and see relationships between fields
  - Perform these operations on very large data
    - ...and on HPC platforms.
  - Want production-quality software, expert help ("fishing instruction")





## Accomplishments Overview

- Made dramatic science understanding impact for multiple science application stakeholders
- Science applications adopt VACET technology as community-wide visual data analysis software infrastructure.
- Stakeholders are voting with their feet.



## We have engaged customers across SciDAC applications, Collaboratories, INCITE, and NSF PetaApps

- Physics
  - “When Good Stars Go Bang”  
–Stan Woosley
  - “A Very Bumpy Ride” –Sanjiva Lele
  - “Shedding New Light on Exploding Stars” –Tony Mezzacappa
  - “Collaborative Research: Supernova Simulation With CHIMERA”  
– Bronson Messer
  - “Community Petascale Project for Accelerator Science and Simulation (ComPASS)”  
–Panagiotis Spentzouris
- Climate
  - “Modeling the Earth System”  
–John Drake
  - “Sharing a World of Data”  
–Dean Williams
  - “The Role of Clouds in Global Climate” –David Randall
- Combustion
  - “Interaction of Turbulence and Chemistry in Lean Premixed Laboratory Flames” –John Bell
  - “High-Fidelity Simulations for Clean and Efficient Combustion of Alternative Fuels” –Jackie Chen
- Fusion
  - “Controlling Fusion Plasmas: Microturbulence” –Bill Nevins
  - “Controlling Fusion Plasmas: Energetic Particle Turbulence”  
–Zhihong Lin
  - “Controlling Fusion Plasmas: Electromagnetic Wave Effects”  
–Paul Bonoli
  - “Modeling Fusion Plasma Stability”  
–Steve Jardin
  - “Petaflops for Gigawatts” –John Cary
  - “Controlling Fusion Plasmas: RF Waves” –Don Batchelor



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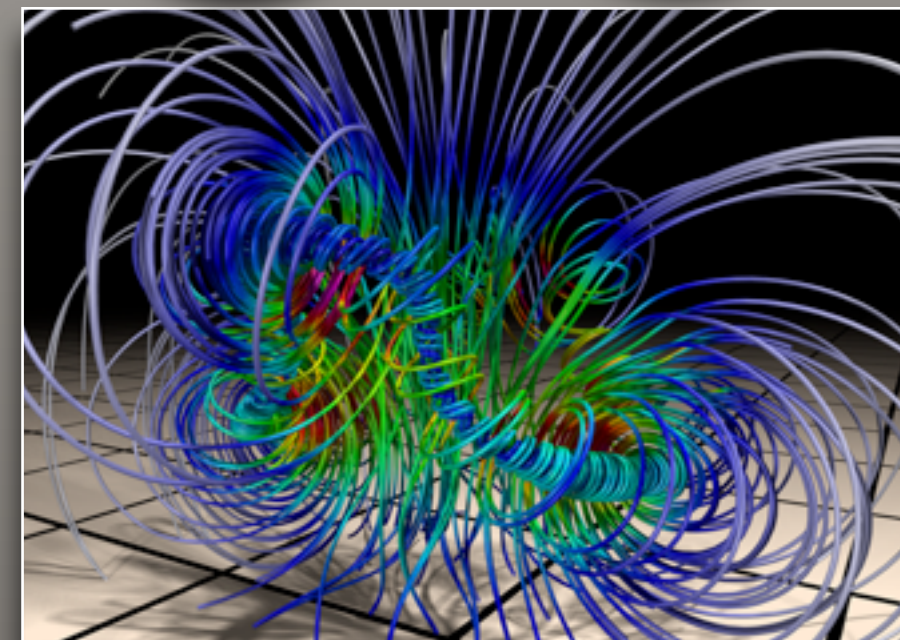
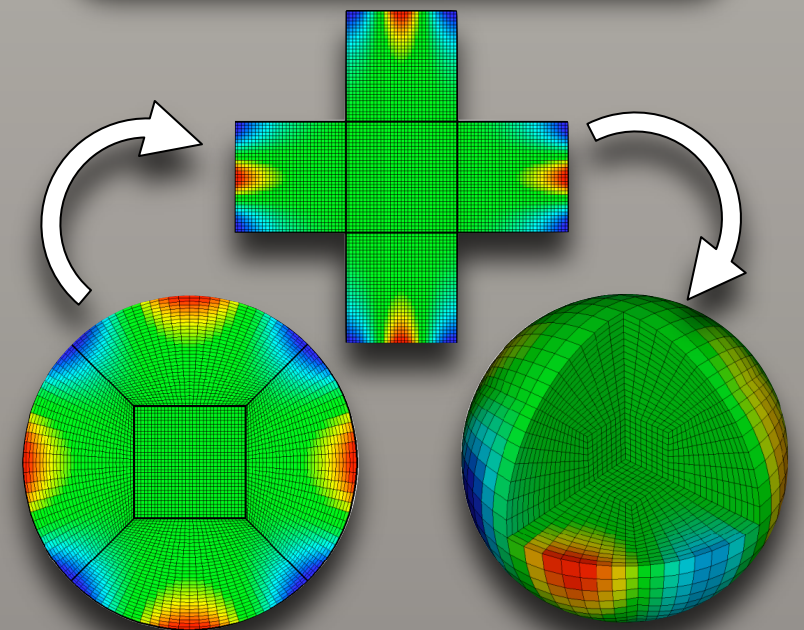
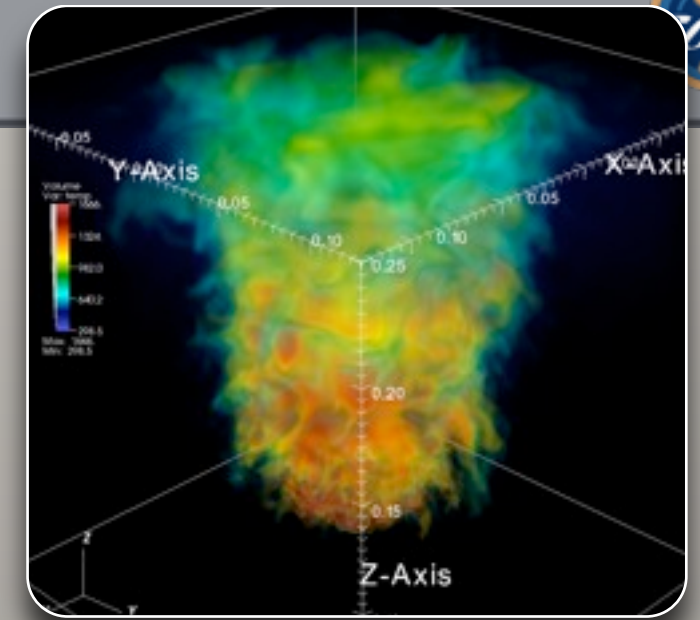


## Specific customer impacts



## Mathematics

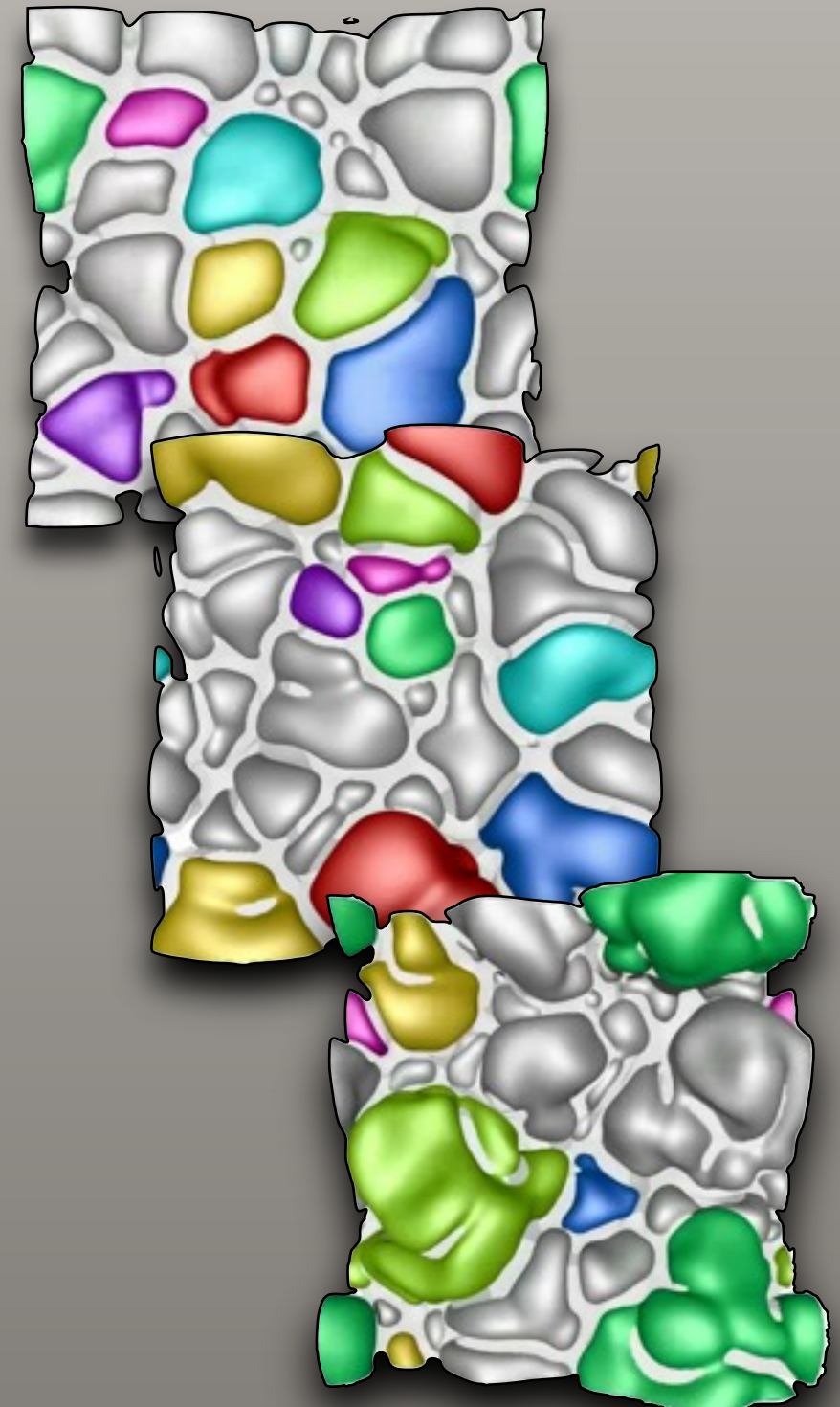
- PI: Phil Colella (LBNL), SciDAC Applied Partial Differential Equations Center
- Accomplishment(s)
  - Software engineering to “bring product to market”. Performance improvements, interface enhancements, file readers, visual data exploration techniques.
- Science Impact
  - Direct cost savings: APDEC no longer uses its own resources (e.g., FTEs) to develop, maintain, and support AMR visualization software.
  - Ability to perform AMR visualization on large, time-varying data, and using parallel platforms.
  - Benefits propagate to all APDEC stakeholders.





## Combustion, Part 1

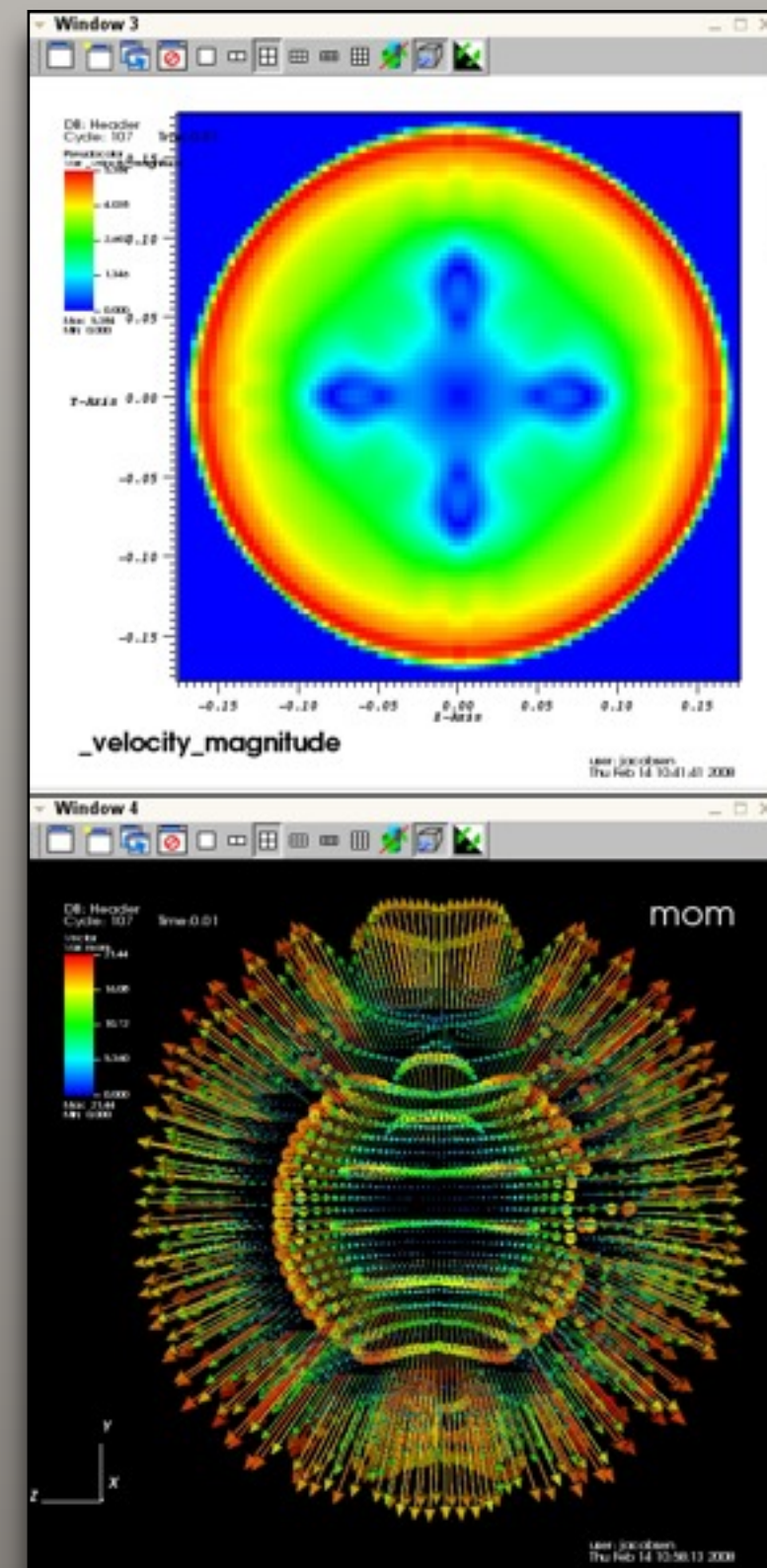
- PI: John Bell (LBNL), INCITE Awardee  
“Interaction of Turbulence and Chemistry in Lean Premixed Laboratory Flames”
- Accomplishments:
  - New topological analysis techniques for studying relationship between parameters and their effect.
  - Joint publications with stakeholder.
- Science Impact:
  - First-ever quantitative analysis of large, time-varying combustion simulation data to study influence of turbulence on size/shape of combustion regions in lean, premixed hydrogen flames.
  - “That’s funny” discovery that stronger turbulence leads to larger cell structures which burn more intensely than expected





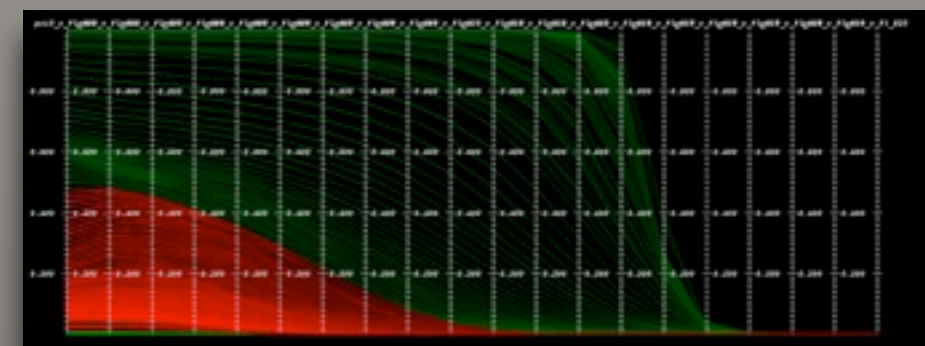
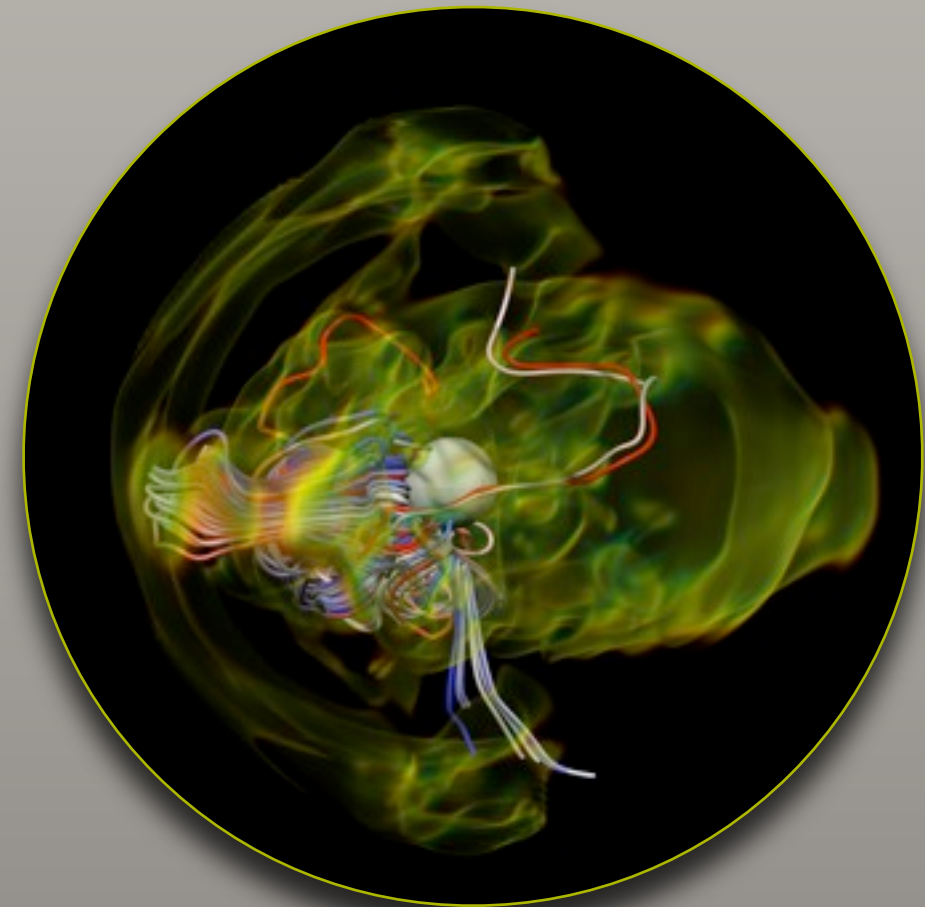
## Astrophysics, Part 1

- PI: Stan Woosley (UCSC), John Bell (LBNL), Adam Burrows (Princeton). SciDAC Community Astrophysics Consortium
- Accomplishment
  - Provide production-quality AMR visualization software, including tutorials and support, to CAC code teams.
- Science Impact
  - Reduced complexity, increase in scientific productivity. A single community-wide visual data analysis application, which addresses needs of SN modeling and spectral analysis, helps eliminate the need to learn and use multiple visual data analysis applications.



## Astrophysics, Part 2

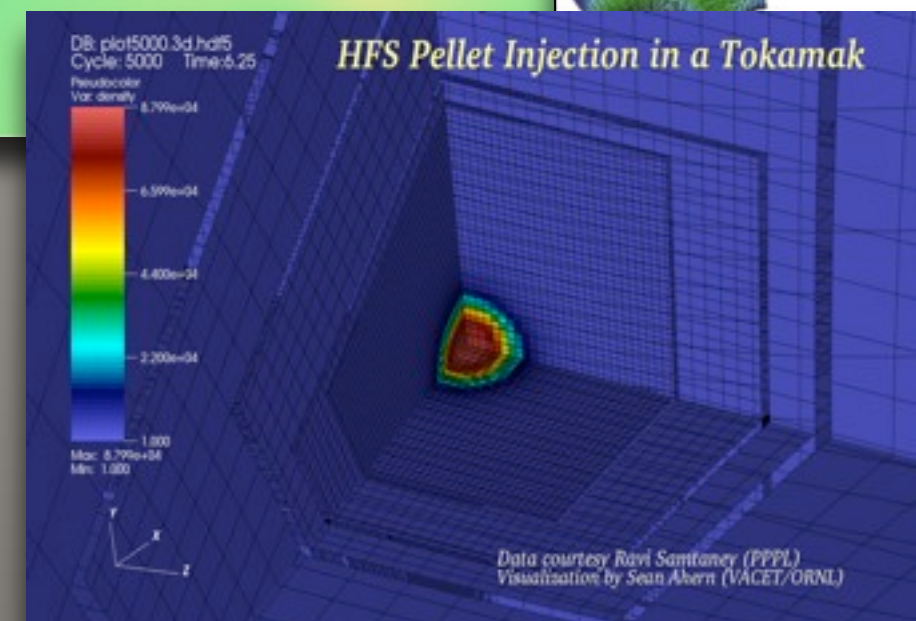
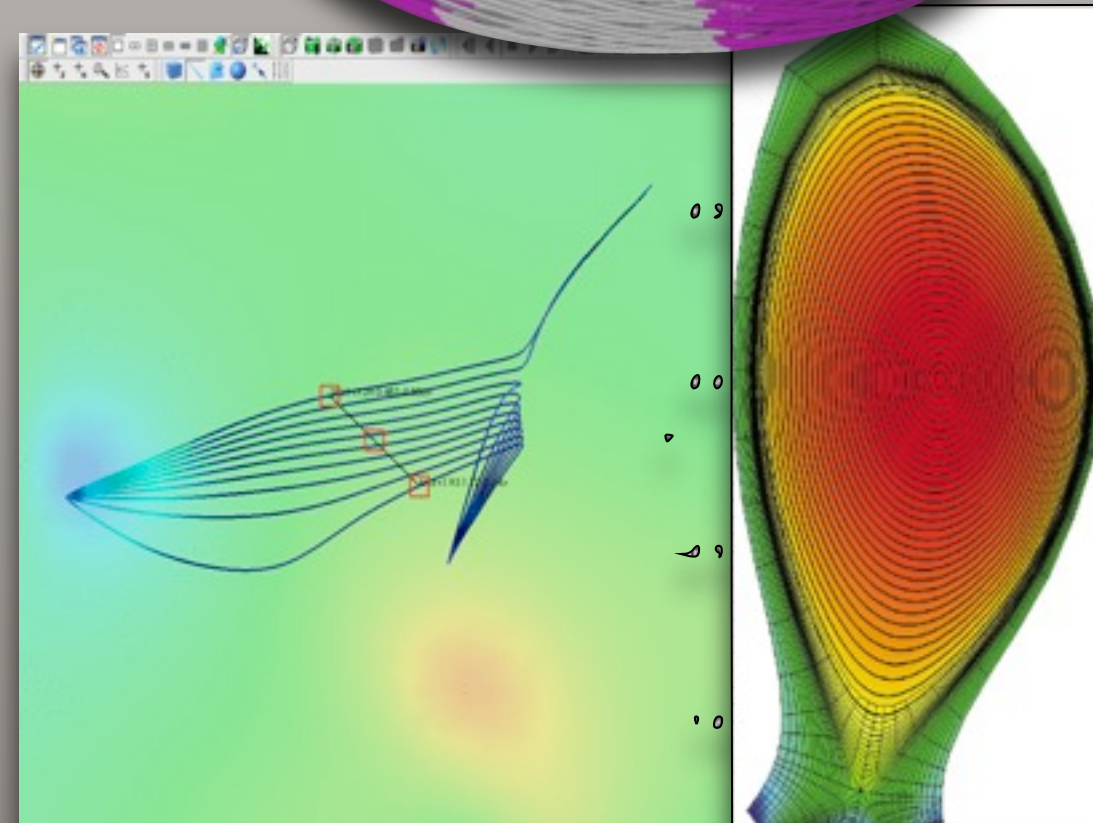
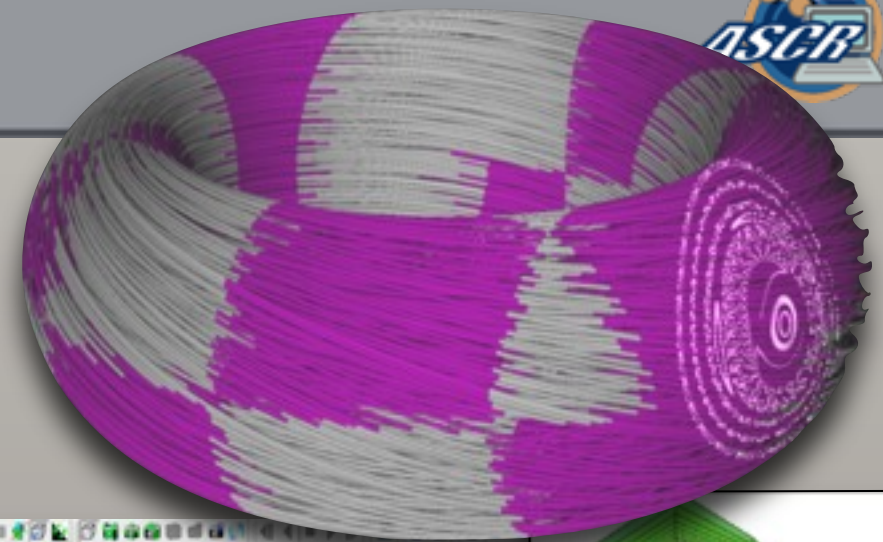
- Pi's/Projects:
  - Tony Mezzacappa (ORNL), INCITE project “Multidimensional Simulations of Core-Collapse Supernovae”
  - Bronson Messer (UT, ORNL), NSF PetaApps project “Supernova Simulations with CHIMERA”
- Accomplishments
  - Provide production-quality custom visualization software, including tutorials and support, to astrophysics code teams.
  - Develop multidimensional visualization and analysis techniques for radiation field exploration
- Science Impact
  - Allowed “first time” visualization of multigroup neutrino radiation field, critical for shockwave development
  - Able to easily explore relationship between simulation parameters (magnetic field and shear)





## Fusion, Part 1

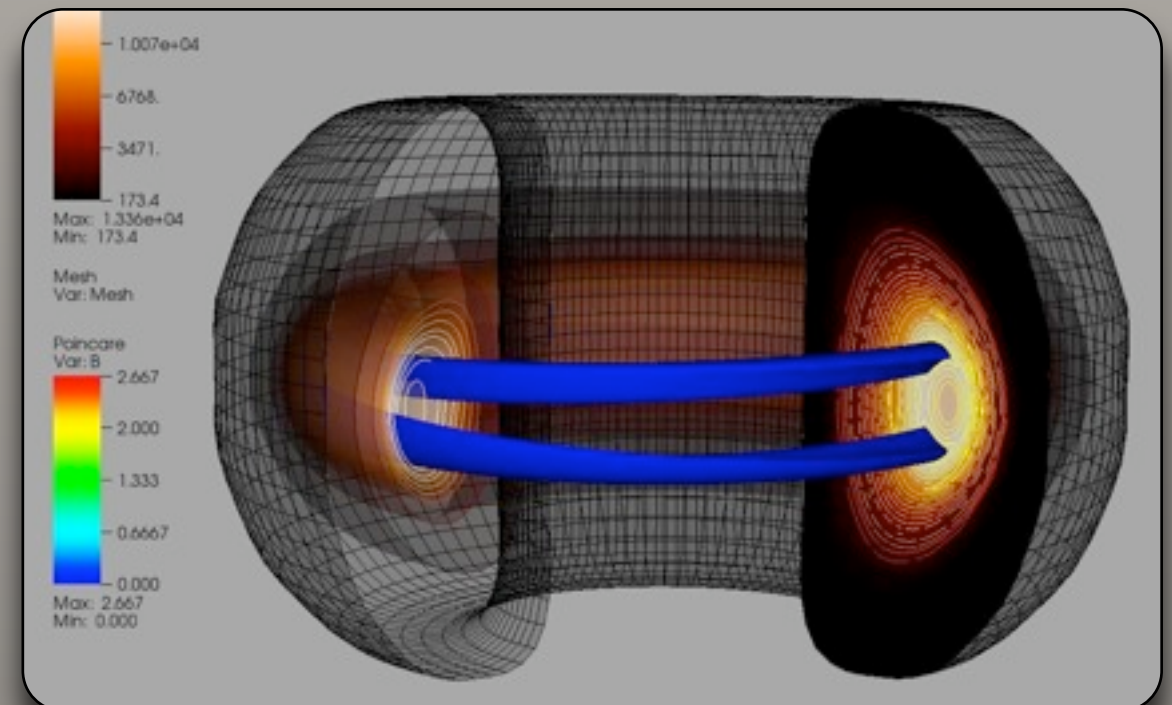
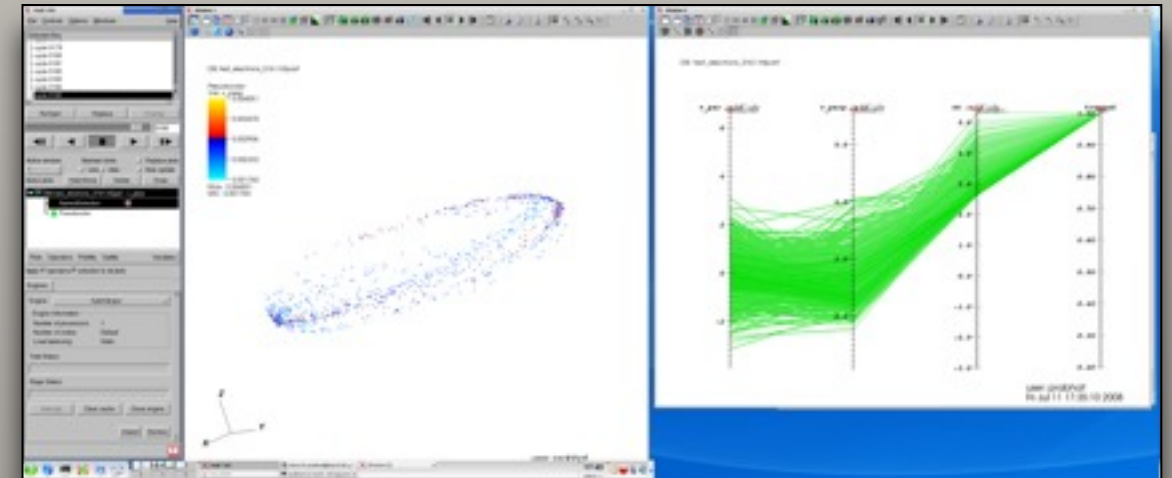
- PI's/Projects
  - J. Cary (Tech-X), SciDAC Framework Application for Core-Edge Transport Simulations
  - Ravi Samtaney (PPPL), SciDAC Center for Extended Magnetohydrodynamic Modeling
- Accomplishment(s)
  - Leverage VACET investment in (1) AMR visualization software and (2) fundamental visualization software infrastructure, along with (3) one-on-one work with user communities to quickly bring “product to market.”
- Science Impact
  - New capability: production quality AMR visualization software infrastructure.
  - Cost savings: community-wide, production-quality visual data analysis software infrastructure helps scientists focus on science rather than visualization software development.





## Fusion, Part 2

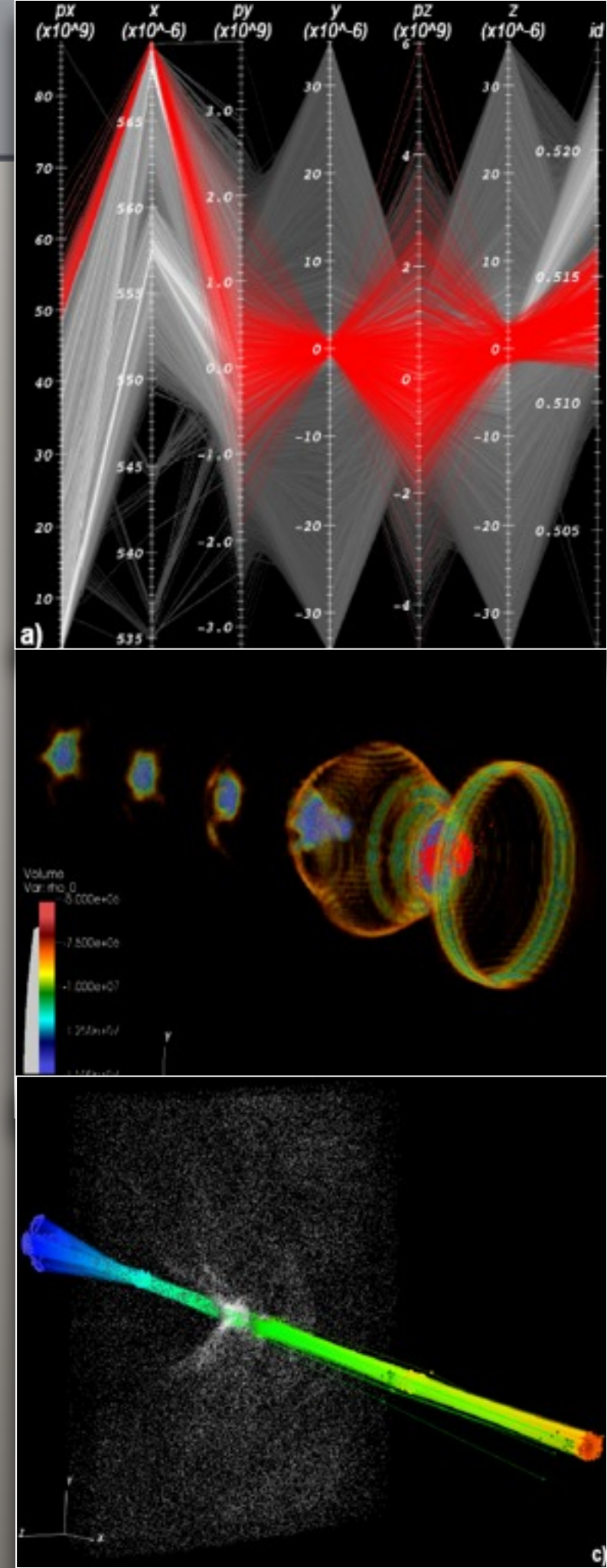
- Fusion Partnership
- PI's:
  - Stephane Ethier (PPPL)
  - Seung-Hoe Ku (NTU), Julian Cummings (CalTech)
  - Scott Kruger (Tech-X), Josh Breslau (PPPL)
  - Bill Nevins (LLNL)
  - Don Batchelor (ORNL), Fred Jaeger (ORNL)
- Objective/Approach
  - These diverse groups have many common needs. Our team is developing/deploying new capabilities to meet these needs in production quality visual data analysis software.
- Impact
  - Enable new science insights in large, complex data.





# Accelerator Modeling

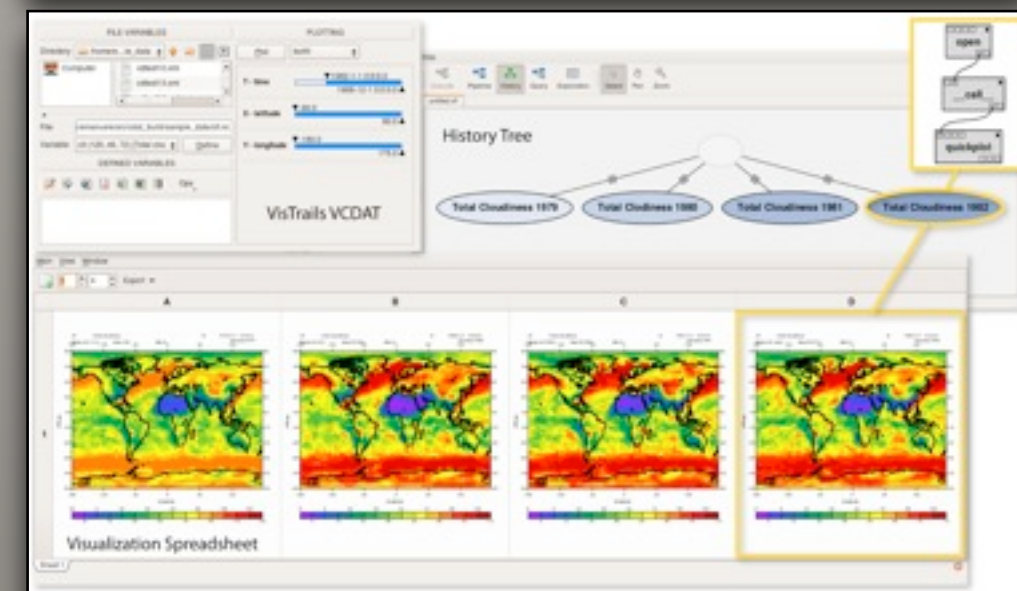
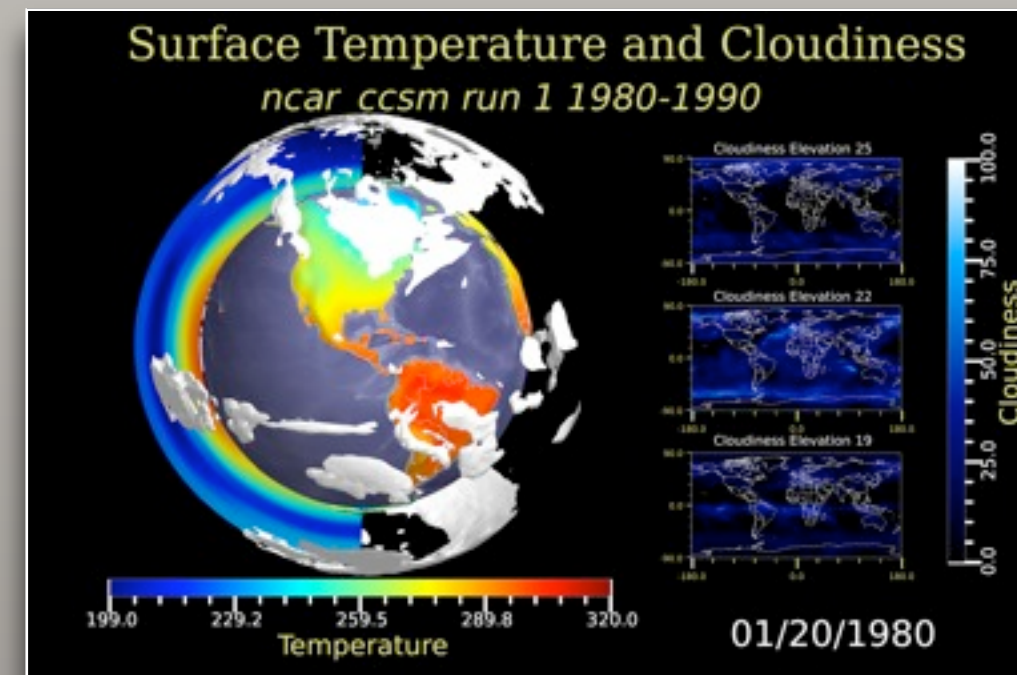
- PI: C. Geddes (LBNL), part of SciDAC COMPASS project, INCITE awardee
- Accomplishment:
  - Algorithms and production-quality software infrastructure to perform interactive visual data analysis (identify, track, analyze beam particles) in multi-TB simulation data.
- Science Impact:
  - Replace serial process that took hours with one that takes seconds.
  - New capability: rapid data exploration and analysis.
- Collaborators:
  - SciDAC SDM Center (FastBit)
  - Tech-X (Accelerator scientists)





## Climate, Part 1

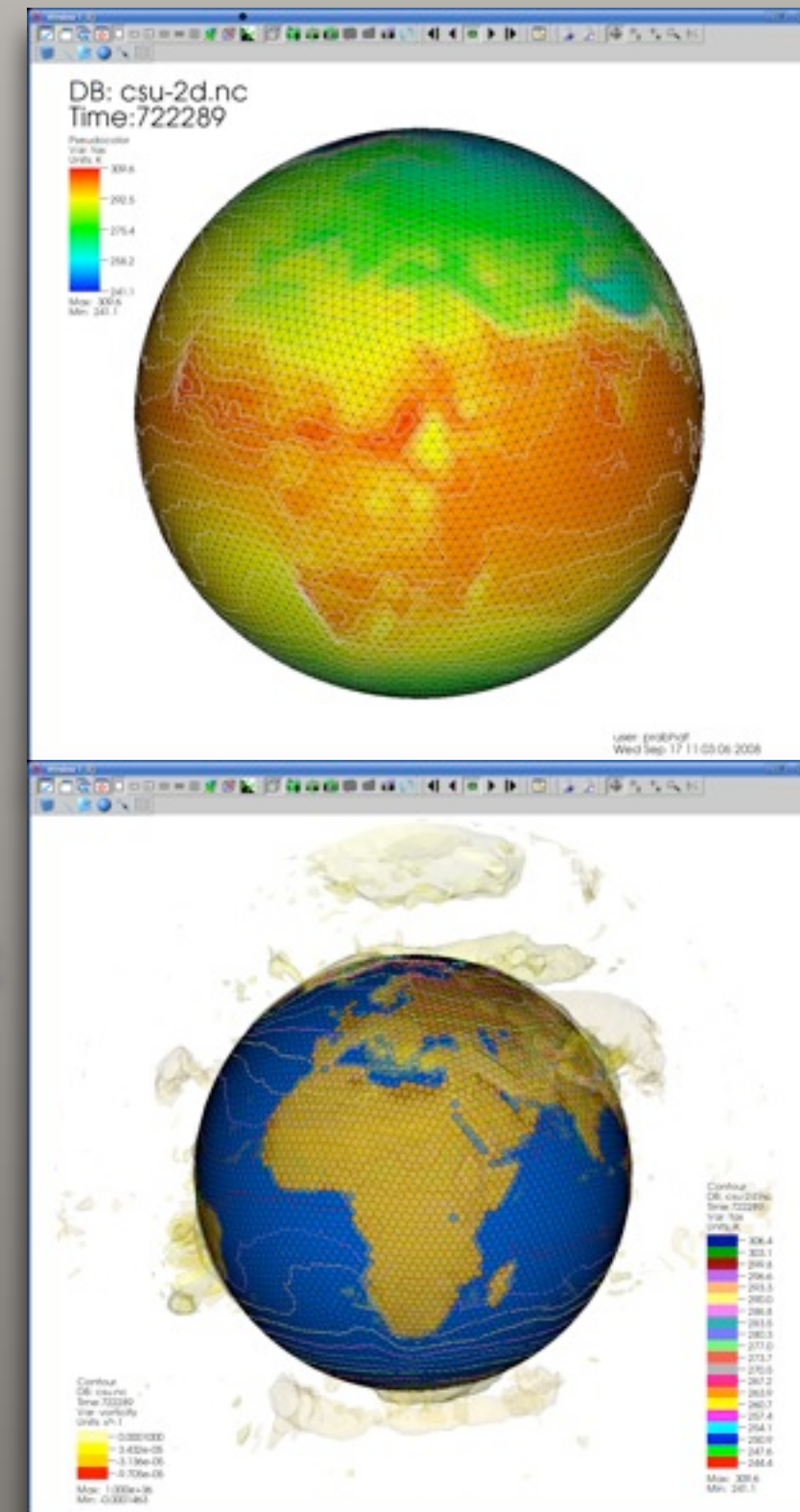
- PI: Dean Williams (LLNL), SciDAC Earth Systems Grid.
  - Other beneficiaries:
    - Community Climate System Model Consortium, Phil Jones (LANL), John Drake (ORNL)
- Accomplishments
  - Software engineering to transition research prototype into production code within a climate community standard visual data analysis system (VCDAT).
  - Automatic provenance tracking of CDAT data analysis sessions
- Science Impacts
  - New capability: 3D temporal visual data analysis is now part of a familiar application, offers new dimensions for understanding climate data.
  - Much greater ability to perform and share comparative climate analysis





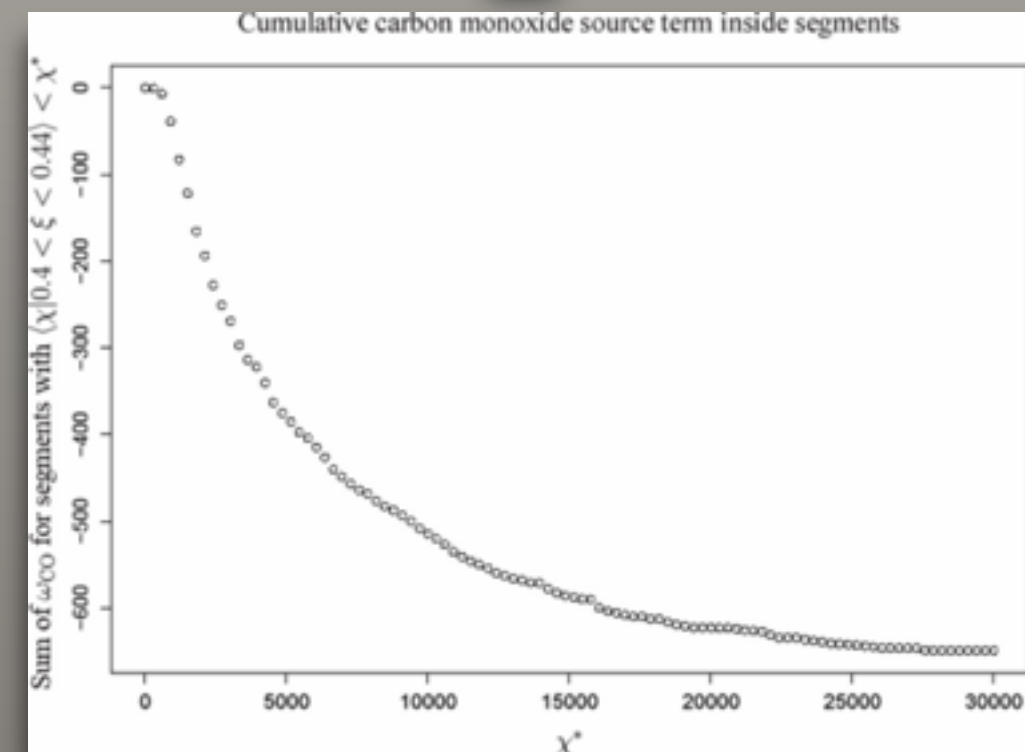
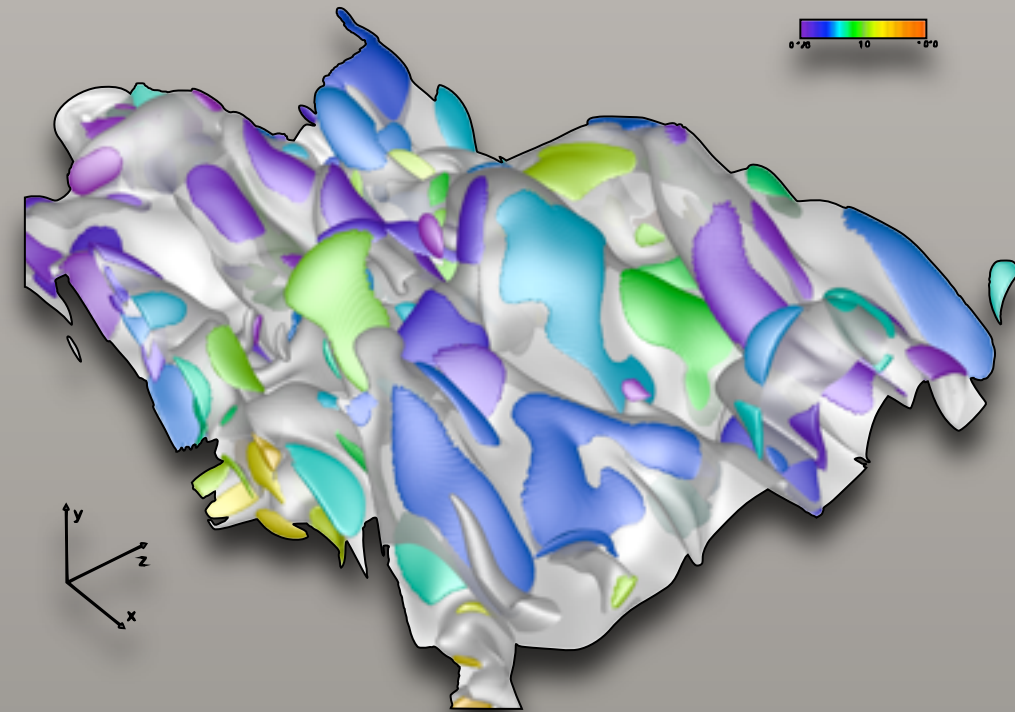
## Climate, Part 2

- PI: Dave Randall (CSU). SciDAC Application: Role of Clouds in Global Climate
- Accomplishments
  - Debug and optimize parallel I/O to meet performance objectives.
  - New visualization infrastructure for icosahedral grid.
- Science Impact
  - Enable effective use of INCITE allocation at NERSC
  - Critical software infrastructure to enable visualization and analysis of ensemble runs of new global cloud models.
- Other Collaborators:
  - NERSC Center staff
  - Karen Schuchardt (PNNL)



## Combustion, Part 2

- PI: Jacqueline Chen (SNL-CA), INCITE awardee
- Accomplishment(s)
  - Algorithms for feature segmentation, tracking, and analysis
  - Co-authors on multiple papers
- Science Impact(s)
  - New capability: first-ever ability to see relationship between simulation parameters (e.g., level of turbulence) and scalar dissipation rate







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## Questions?